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(54) **FILLING ELEMENT, METHOD AND FILLING SYSTEM FOR FILLING CONTAINERS**

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See application file for complete search history.

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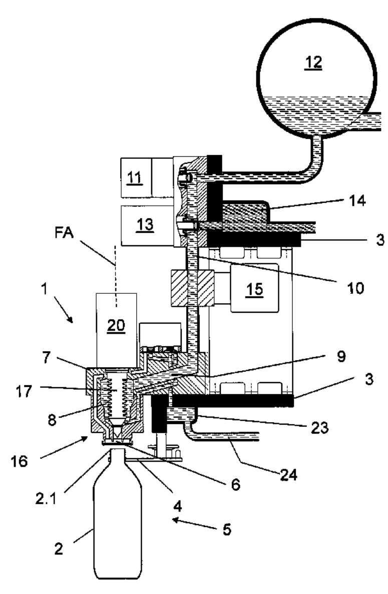
(57) **ABSTRACT**

A filling element for free jet filling of containers with a liquid charge includes a housing having a liquid channel formed therein, a liquid valve provided upstream of a dispensing opening, and an actuator device for actuating the liquid valve for controlled discharge of the liquid charge via the dispensing opening into a container arranged with a container opening thereof spaced below the dispensing opening. In an open state thereof, the liquid valve forms an opening gap through which the liquid charge flows. This opening gap has a gap width of at least four millimeters. The actuating device for the liquid valve is configured to cause the liquid valve to be in the open state for at least one hundred milliseconds.

17 Claims, 3 Drawing Sheets



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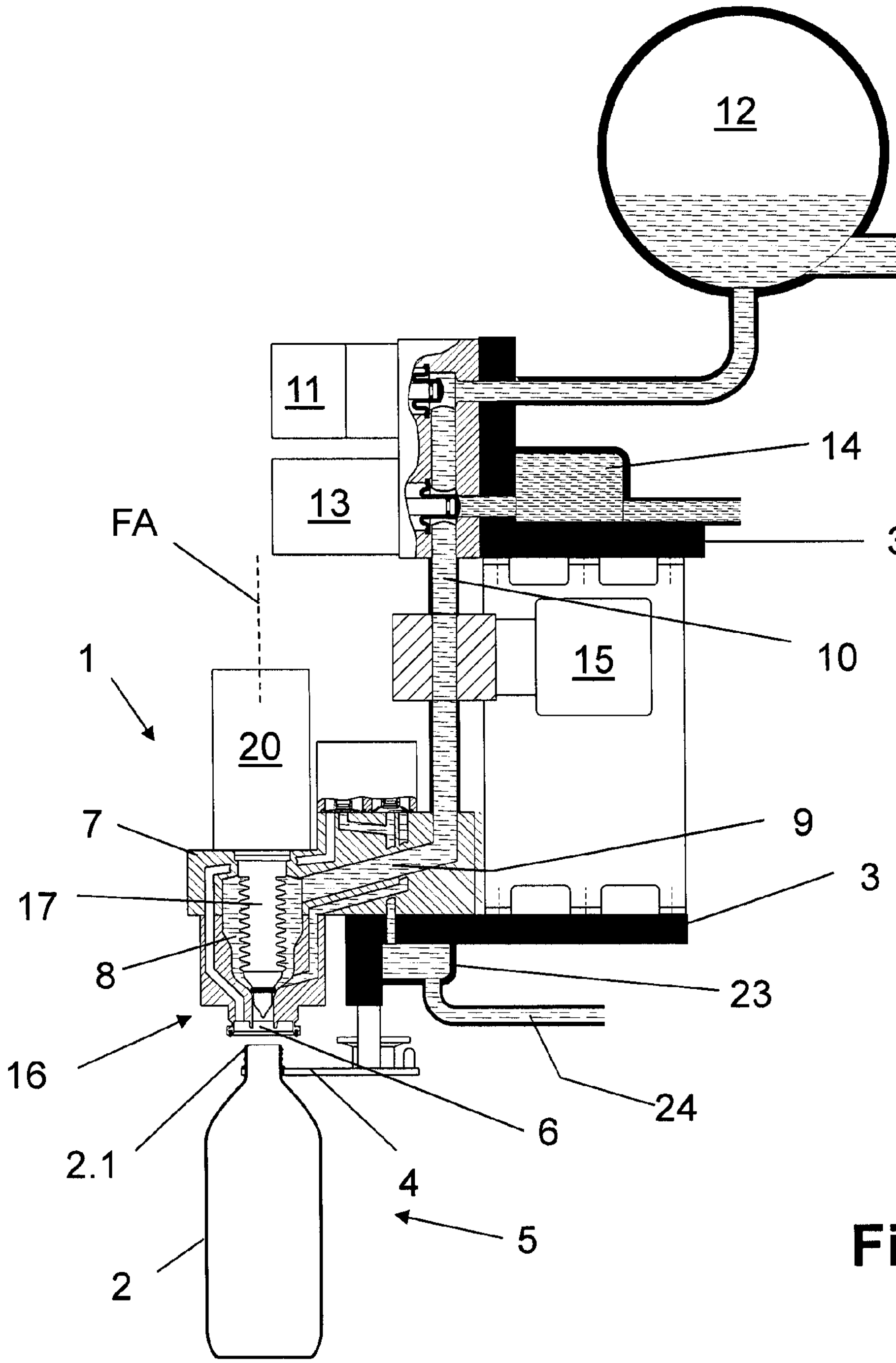

Fig. 1

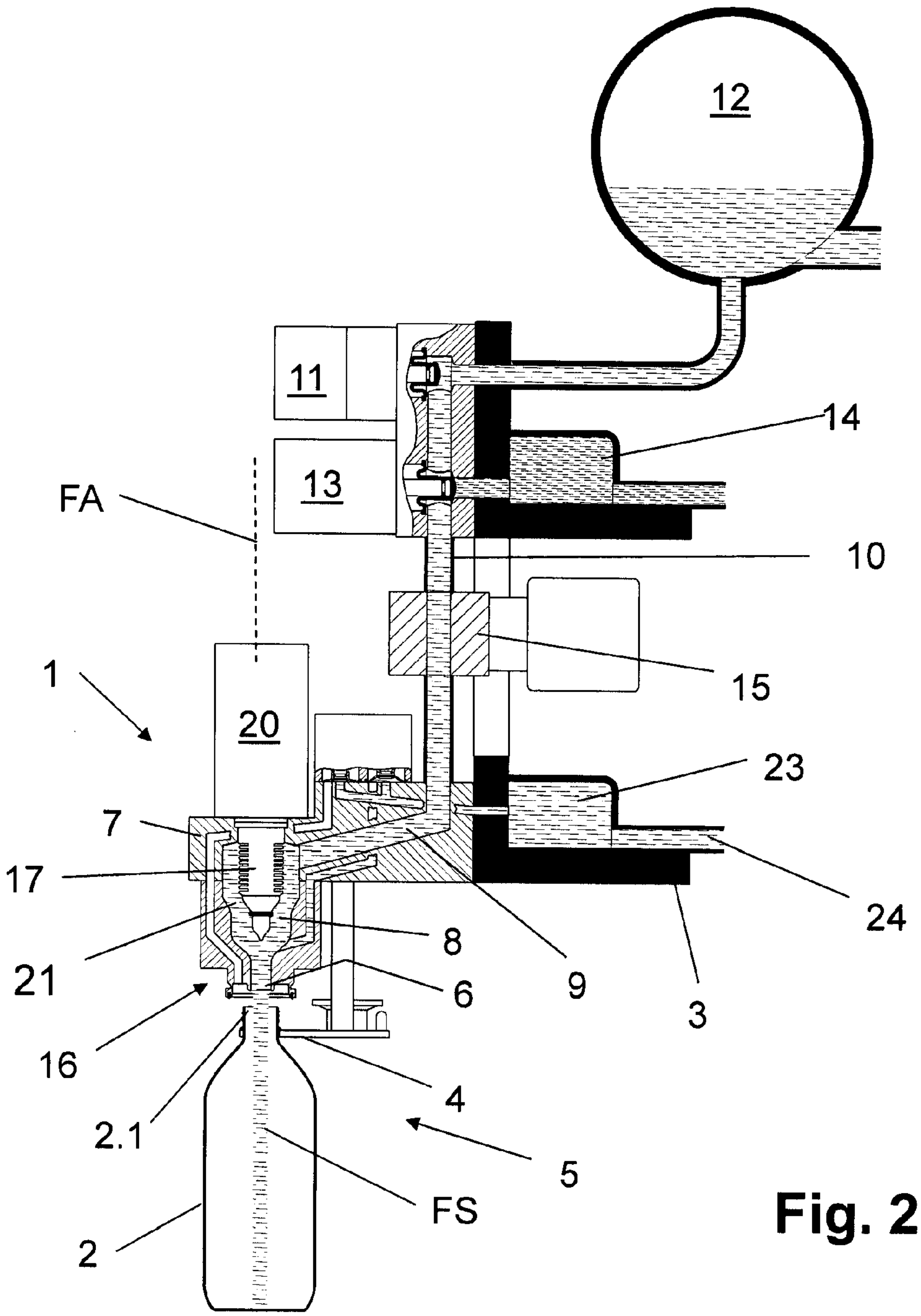

Fig. 2

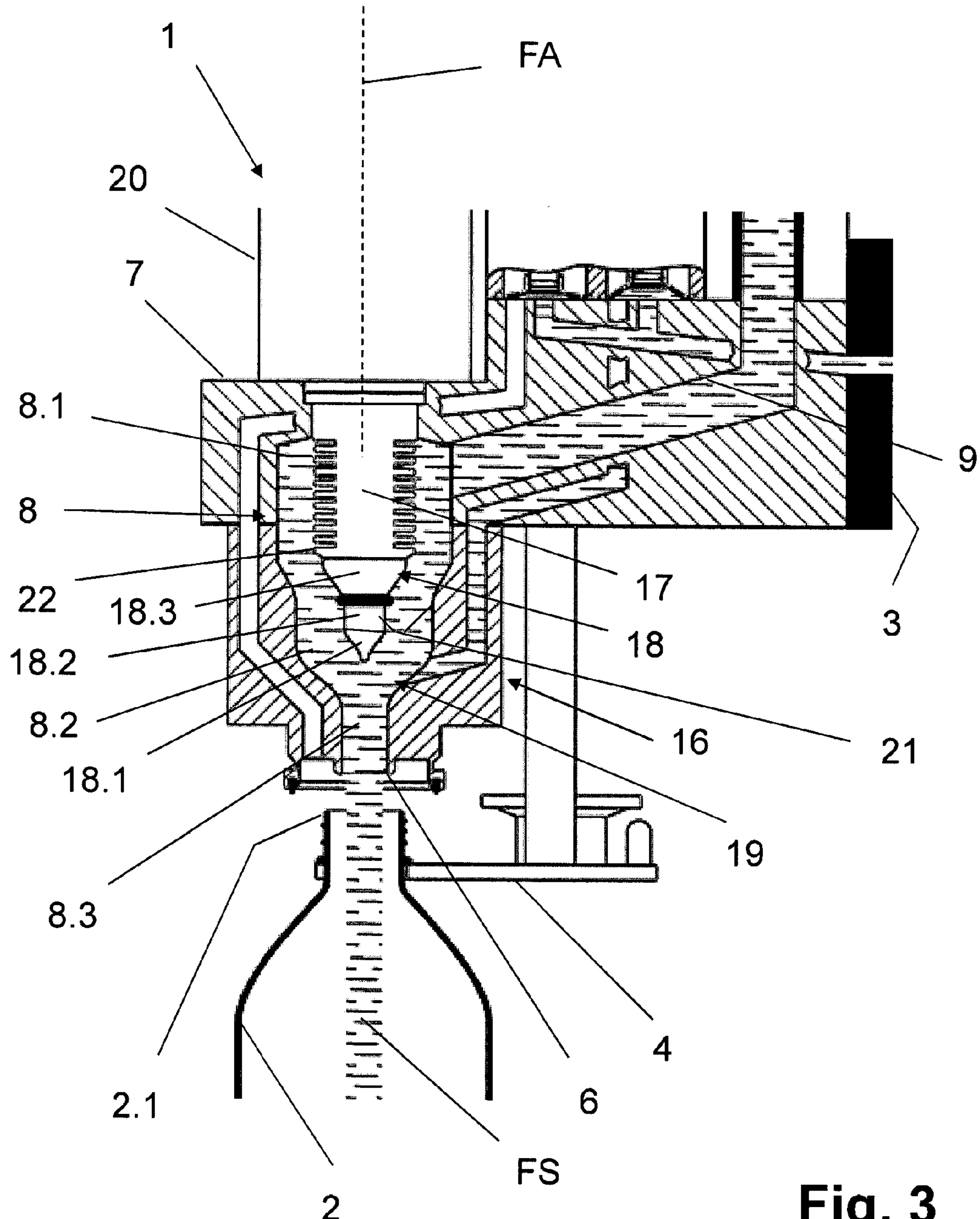

Fig. 3

FILLING ELEMENT, METHOD AND FILLING SYSTEM FOR FILLING CONTAINERS

CROSS REFERENCE TO RELATED APPLICATION

This application is the national phase under 35 USC 371 of international application no. PCT/EP2011/002424, filed May 17, 2011, which claims the benefit of the priority date of German application no. 10 2010 027 511.5, filed Jul. 16, 2010. The contents of the aforementioned applications are incorporated herein in their entirety.

FIELD OF DISCLOSURE

The invention concerns a filling element for filling containers with a liquid charge in the form of a free jet.

BACKGROUND

A fundamental problem of known filling systems is that of preventing ambient air from penetrating through a dispensing opening and into the liquid channel of valve chamber of a filling element. It is important to do so because air that has penetrated into the liquid channel causes air bubbles that eventually rise into the product lines and finally into the boiler that supplies liquid charge to all the filling elements of the filling system. This can lead to contamination of charge in the product lines and in the boiler. It can also lead to loss of measurement accuracy because rising air bubbles may interfere with operation of flow meters or other measurement devices.

In known filling elements, an actuator opens the liquid valve as quickly and completely as possible. In these known filling elements, a valve can be completely open within as few as 50 milliseconds.

A liquid valve has a gap across its opening. The width of this gap when the valve is fully open is known to have an effect on how much air penetrates into the channel. According to generally established opinion, an effective way to prevent air from penetrating into the liquid channel of the filling element is to make make the width of this gap as small as possible. In most known filling systems, the gap width is approximately 1.0 mm to 1.5 mm.

An additional way to suppress entry of ambient air is to use a gas lock in the liquid channel. A gas lock has a multiplicity of passages, each with minimum flow cross section. These narrow passages make it difficult for ambient air to penetrate and thus suppress formation of air bubbles rising in the filling element and in the product lines.

These known free-jet filling elements are effective when the contents of the container are purely liquid. However, in some cases, the contents include solid constituents. For example, fruit juices may include suspended solids such as fruit flesh and/or fruit fibers, or pulp. These products require gap sizes or gap widths for the gap of the open filling element of more than 3 millimeters. This is much greater than the usual range of 1-1.5 millimeters that has been found effective to reduce ingress of air.

Obviously, making the gap wide enough to accommodate fruit pulp and the like would likely lead to the penetration of air bubbles into the liquid channel and via the product channels or lines into the product boiler.

SUMMARY

An object of the invention is to develop a free-jet filling element in which the gap width of a gap formed when the

liquid valve is fully opened is large enough to allow free-jet filling of products with solid constituents without the risk of ambient air penetrating into the liquid channel of the filling element, and hence without the risk of air bubbles rising into the liquid channel of the filling elements and into the product lines.

The invention is based on the surprising discovery that if a valve is opened more slowly, ambient air is less likely to penetrate into the liquid channel of the filling element.

It is believed that by opening the valve more slowly, for example by taking at least 100 milliseconds to fully open a valve, one avoids excessive agitation of the charge within the liquid channel. This, in turn, avoids the entry of ambient air in the filling system.

The invention also ensures that the, when the liquid valve is opened, the liquid in the charge column above the valve and in the product lines leading to the filling element moves with high acceleration.

The acceleration of the charge column present is sufficiently high if the flow cross-section for the liquid charge that results during the opening of the liquid valve is filled completely and immediately with the charge and the charge flows through the flow cross-section with sufficient flow speed so there is no chance of penetration of ambient air. This high acceleration results in part from having the charge flow through a gap that is larger than those conventionally used.

In a preferred embodiment of the invention, the opening time of the liquid valve is greater than 100 milliseconds but smaller than 1000 milliseconds.

Preferably, the opening time lies in the range between 400 milliseconds and 600 milliseconds. In some embodiments, the gap width of the gap through which charge flows when the liquid valve is completely opened is greater than 4 millimeters. In other embodiments, it is greater than 8 millimeters but less than 20 millimeters, and in yet other embodiments, it is between 13 and 16 millimeters. The filling element according to the invention is designed without a gas lock.

In some embodiments of the invention, the liquid valve's opening speed is variable. In some of these embodiments, the opening speed rises as the gap width increases. In some embodiments, the opening speed adapts to the acceleration behavior of the product column present in the filling element or at the liquid valve so that a full charge jet can always be achieved. This will safely avoid the penetration of air bubbles with minimum filling times.

Adaptation of the opening speed is achieved, for example, by corresponding geometric design of the liquid valve or the valve body of the liquid valve and/or those segments of the liquid channel that hold this valve body at least at the start of the opening of the liquid valve, and/or by corresponding formation and/or control of an actuator device for the liquid valve or its valve body.

As used herein, the term "substantially" includes deviations from the precise value concerned by ±10%, preferably ±5%, and/or deviations in the form of changes not significant for the function.

As used herein, "free-jet filling" refers to a method in which the liquid charge flows to the container to be filled in the form of a free jet of liquid, and in which the container's mouth or opening does not lie against the filling element but is spaced from the filling element or a dispensing opening thereof. An essential feature of this method is also that the air displaced from the container by the liquid product during the filling process does not enter the filling element or a gas-carrying region or channel formed therein but flows freely into the environment.

An "gap," as used herein, refers to the usually annular gap that is formed in the region of the liquid valve when the valve opens to pass liquid charge and through which flows the liquid charge towards the dispensing opening, emerging at the dispensing opening as a free jet of liquid charge.

As used herein, "gap width" refers to a width of the gap, preferably the minimum width of the gap when, for example, the gap has a spatially-varying width.

As used herein, the "opening time" of the liquid valve is the time span between the time at which the valve begins to open and the time at which it is fully open.

The "opening speed" of the liquid valve is the time-dependent change in opening or flow cross-section of the gap on opening of the liquid valve.

As used herein, "containers" refers to general packaging means that are normally used for liquid and/or paste-like products, in particular drinks, for example soft packaging formed from flat material, containers of metal, glass and/or plastic, for example cans, bottles etc.

Refinements, advantages and possible applications of the invention arise from the description below of embodiment examples and from the figures. All features described and/or shown in diagrams in themselves or in any combination are in principle the subject of the invention. Also the content of the claims is an integral part of the description.

BRIEF DESCRIPTION OF THE FIGURES

These and other features of the invention will be apparent from the following detailed description and the accompanying figures, in which:

FIG. **1** shows, in simplified depiction and in cross-section, a filling element of a filling system or a filling machine for free-jet filling of containers in the form of bottles with a liquid charge which may also contain solid constituents, with the liquid valve closed;

FIG. **2** shows the filling element of FIG. **1** with the liquid valve open; and

FIG. **3** shows an enlarged part view of the opened liquid valve.

DETAILED DESCRIPTION

FIG. **1** shows a filling element **1** for free-jet filling of bottles **2** with a charge. The charge has two constituents. A first constituent is mostly liquid. A second constituent is mostly solid. An example of a liquid constituent is fruit juice. An example of a solid constituent is fruit fiber, fruit flesh, pulp, and/or fruit pieces suspended in a liquid suspension medium.

The filling element **1**, together with a container carrier **4**, form a filling position **5** that is one of a multiplicity of similar filling positions **5** on the periphery of a rotatable rotor **3**.

During filling, the container carrier **4** suspends a bottle **2** by its opening flange with its bottle opening **2.1** arranged below and separated from a dispensing opening **6** of the filling element **1**. The container carrier **4** suspends the bottle **2** so that the bottle **2** is coaxial or substantially coaxial with a vertical filling-element axis FA. As a result, during filling, charge flows into the bottle **2** as a free charge jet FS, best seen in FIG. **2**.

The filling element **1** includes a housing **7** in which is formed a liquid channel **8**. This liquid channel **8** defines a valve chamber of a liquid valve **16**. A lower end of the liquid channel **8** has a dispensing opening **6** through which charge flows in response to opening and closing of the liquid valve **16**. An upper end of the liquid channel **8** connects, via a product-channel segment **9**, with the lower end of a product channel **10**. In the illustrated embodiment, the product channel **10** is vertical.

At an upper region thereof, the product channel **10** connects to both a boiler **12** and a ring channel **14**. During the filling operation, the boiler **12** and the ring channel **14** contain the first and second charge constituents respectively. A first metering valve **11** between the product channel **10** and the boiler **12** meters the quantity of the first constituent. A second metering valve **13** between the ring channel **14** and the product channel **10** meters the quantity of the second constituent. All the filling elements **1** on the rotor **3** are connected to the same boiler **12** and ring channel **14**.

A flow meter **15** arranged in the product channel **10** supplies a signal corresponding to the charge flow through the product channel **10**. This signal is provided to a central control unit, such as a computer-supported machine controller. In some embodiments, the flow meter is an electromagnetic flow meter.

The signal from the first and second metering valves **11**, **13** provides a basis for adjusting a mixing ratio of the two components based on a recipe. The signal from the flow meter **15** provides a way to tell if enough charge has been introduced into a bottle **2** so that the liquid valve **16** can be closed.

Referring to FIG. **3**, the liquid valve **16** comprises a tappet **17** that is coaxial with the filling-element axis FA. A lower end of the tappet **17** forms a valve body **18** with a valve-body seal that concentrically surrounds the filling-element axis FA. The valve-body seal cooperates with a valve surface formed on a conical surface **19** of the liquid channel **8** to close the liquid valve **16**. The conical surface **19** is rotationally symmetric relative to the filling-element axis FA.

An actuator **20** opens and closes the liquid valve **16** by moving the valve tappet **17**, with its valve body **18**, along the filling-element axis FA between a closed position, shown in FIG. **1**, and an open position, shown in FIG. **2**. In the closed position, the valve body **18** lies with its valve body **18** sealed against the valve face formed by the conical surface **19**. In the opened position, a ring-shaped gap **21** forms between the valve body **18** and the conical surface **19**.

When the valve is fully-opened, the ring-shaped gap **21** has a substantial gap width. In some embodiments, the gap width exceeds 4 millimeters. In other embodiments, the gap width is between 8 millimeters and 20 millimeters. In yet other embodiments, the gap width is between 13 millimeters and 16 millimeters. These large gap widths permit problem-free filling of the bottles **2** with a mixture made from the first and second constituents.

As shown in detail in FIG. **3**, the valve tappet **18** has a first valve-body-segment **18.1**, a second valve-body-segment **18.2**, and a third valve-body-segment **18.3**. The first valve-body-segment **18.1** is closest to a lower free end of the valve tappet **17**. The third valve-body-segment **18.3** is furthest from the lower free end of the valve tappet **17**. The second valve-body-segment **18.2** is between the first valve-body-segment **18.1** and the third valve-body-segment **18.3**.

The first valve-body-segment **18.1** is conical and tapers from a first diameter to a second diameter that is smaller than the first diameter. The portion of the first valve-body-segment **18.1** that has the second diameter is that portion that is closest to the lower free end of the valve tappet **17**. The portion of the first valve-body-segment **18.1** that has the first diameter is that portion that is furthest from the lower free end of the valve tappet **17**.

The second valve-body-segment **18.2** is a cylindrical segment having a diameter equal to the first diameter.

The third valve-body-segment **18.3** is a frusto-conical segment that has a diameter ranging in value from the first diameter to a third diameter that is greater than the first diameter. The portion of the third valve-body-segment **18.3** that has the first diameter is that portion that adjoins the second valve-body-segment **18.2**. The portion of the third valve-body-segment **18.3** that has the third diameter is that portion that is furthest from the second valve-body-segment **18.2**. The first valve-body-segment **18.1**, the second valve-body-segment **18.2**, and the third valve-body-segment **18.3** are all coaxial with the filling-element axis FA.

Referring to FIG. **3**, a bellows **22** tightly surrounds that portion of the valve tappet **17** lying above and adjacent to the third valve-body-segment **18.3**. The bellows **22** seal the passage of the valve tappet **17** through the housing **7**. At the same time, the bellows **22** have an outer diameter that is the same or substantially the same as the third diameter. This avoids having flat segments facing away from the dispensing opening **6**. This, in turn, suppresses a suction effect from the dispensing opening **6** into the liquid channel **8** that can otherwise occur when the liquid valve **16** opens. Suppression of this suction effect in turn suppresses agitation of charge present in the liquid channel **8** upon opening the liquid valve **16**. This, in turn, reduces entry of ambient air into the liquid valve **16**.

In the embodiment shown, the liquid channel **8** is made of a first channel-segment **8.1**, a second channel-segment **8.2**, a third channel-segment **8.3**, and a fourth channel-segment **8.4**.

The fourth channel-segment **8.4** ends at the dispensing opening **6**. The third channel-segment **8.3** adjoins the fourth channel-segment **8.4**. The first channel-segment is furthest from the dispensing opening **6**. The second channel-segment **8.2** is between the first channel-segment **8.1** and the third channel-segment **8.3**. The first channel-segment **8.1**, the second channel-segment **8.2**, the third channel-segment **8.3**, and the fourth channel-segment **8.4** are all coaxial with the filling-element axis FA.

The first channel-segment **8.1** is defined in part by a cylindrical or substantially cylindrical wall having a first diameter. The product-channel segment **9** empties into this first channel-segment **8.1**.

The second channel-segment **8.2** is defined in part by a cylindrical or substantially cylindrical wall having a second diameter. The second diameter is smaller than the first diameter. The cross-sectional area of the second channel-segment **8.2** is smaller than the cross-sectional area of the first channel-segment **8.1**.

The third channel-segment **8.3** is defined in part by the conical surface **19** and thus tapers like a hopper in the direction towards the underside of filling element **1**. The diameter of the third channel-segment **8.3** is greatest where it adjoins the second channel-segment **8.2** and is smallest where it adjoins the fourth channel-segment **8.4**.

The fourth channel-segment **8.4** has a circular cylindrical cross-section and ends with the dispensing opening **6**.

When the liquid valve **16** is closed, the first valve-body-segment **18.1** is mostly within the fourth channel-segment **8.4** and the third valve-body-segment **18.3** is mostly within the third channel-segment **8.3**.

On first opening of the liquid valve **16**, the first and second valve-body-segment **18.1**, **18.2** move upward into the second channel-segment **8.2**. In the fully opened state of the liquid valve **16**, the valve body **18** is held in the second channel-segment **8.2** and the gap **21** attains its maximum width.

To avoid penetration of air bubbles into the liquid channel **8** on opening the liquid valve **16** despite the large opening width of the gap **21**, the actuator **20** opens the liquid valve **16** with a greatly reduced opening speed. In some embodiments, it takes more than 100 milliseconds to open the liquid valve **16**. In others, it takes between 100 milliseconds and 1000 milliseconds to fully open the liquid valve **16**. In yet other embodiments, it takes between 400 milliseconds and 600 milliseconds to fully open the liquid valve **16**.

The effect achieved by the relatively slow opening of the liquid valve **16**, namely that of avoiding penetration of air bubbles in the liquid channel **8** despite the greater gap width of the gap **21**, is also supported by the geometry of the valve tappet **17** and the valve body **18** in the manner described above. The valve tappet **17** and valve body **18** are configured to avoid agitation of the product in the liquid channel **8** and/or flat areas that would cause a suction effect on opening the liquid valve **16**. In particular, when opening the liquid valve **16**, the gap **21** is only or substantially only formed after the second valve-body-segment **18.2** has emerged from the fourth channel-segment **8.4**. The gap **21** enlarges only slowly as long as the first valve-body-segment **18.1** is still in the fourth channel-segment **8.4**. As the opening process continues, and as a result of the geometry of the liquid valve **16**, the gap **21** continues to enlarge, but slowly, until finally the maximum opening cross-section or maximum gap width of the gap **21** is reached.

The opening speed of the liquid valve **16** is selected so that the acceleration of the charge column in the liquid channel **8** is sufficient so that the additional flow or opening cross-section that results from the increasing opening of liquid valve **16** is filled in each case directly and completely with the charge that ultimately flows through the gap **21** at a flow rate that is high enough to avoid the penetration of air into the liquid valve **16**.

The possibility also exists of controlling the opening speed of the liquid valve **16** by corresponding control and/or design of an actuator **20**. In particular, the actuator **20** opens the liquid valve **16** in a manner adapted to the acceleration behavior of the charge column present in the liquid channel **8** so that a complete charge jet FS can always be achieved. This tends to thwart penetration of air or air bubbles while nonetheless yielding a filling time that is as short as possible.

Some embodiments also include a heating channel **23** and heated-product line **24** that is common to all filling elements **1**. These cooperate to form a heating circuit that either heats the charge or maintains hot charge at a desired temperature.

The invention has been described above in the context of a single example. It is evident that numerous changes and derivations are possible without departing from the fundamental concept of the invention.

Having described the invention, and a preferred embodiment thereof, what is claimed as new, and secured by Letters Patent is:

1. An apparatus comprising a filling element for free-jet filling of containers with a liquid charge, said filling element comprising a filling-element housing comprising a liquid channel formed therein, a liquid valve provided upstream of a dispensing opening, and an actuator device for actuating said liquid valve for controlled discharge of said liquid charge via said dispensing opening into a container arranged with a container opening thereof spaced below said dispensing opening, wherein, in an open state thereof, said liquid valve, when completely open, forms an gap through which said liquid charge flows, said gap having a gap width of at least four millimeters, and wherein said actuating device for said liquid valve is configured to cause said liquid valve to reach said completely open state only after more than one hundred milliseconds from actuation thereof.

2. The apparatus of claim **1**, wherein said gap width is between eight millimeters and twenty millimeters.

3. The apparatus of claim 1, wherein said gap width is between thirteen millimeters and sixteen millimeters.

4. The apparatus of claim 1, wherein said actuating device is configured to cause the time for said liquid valve to reach said completely open state to be between one hundred milliseconds and one thousand milliseconds.

5. The apparatus of claim 1, wherein said actuating device is configured to cause a time for said liquid valve to reach said open state to be between four hundred milliseconds and six hundred milliseconds.

6. The apparatus of claim 1, wherein the liquid valve comprises a valve body comprising a valve body segment that, upon commencement of opening of said liquid valve, moves along a segment of said liquid channel, wherein said valve body segment and said liquid channel segment are configured to have a geometry such that a width of said gap formed between said valve body segment and an inner face of said liquid channel segment on first opening of said liquid valve increases as said liquid valve is opened further, and wherein said liquid valve comprises an inner cross section that expands in a direction of opening movement of said valve body.

7. The apparatus of claim 1, wherein said valve body comprises a valve tappet, and wherein said valve tappet has an outer diameter that is the same as a maximum outer diameter of said valve body.

8. The apparatus of claim 1, wherein said valve body comprises a valve tappet, and wherein an element surrounding said valve tappet has an outer diameter that is the same as a maximum outer diameter of said valve body.

9. The apparatus of claim 1, further comprising a bellows, wherein said valve body comprises a valve tappet, wherein said bellows surround said valve tappet, and wherein said bellows have an outer diameter that is the same as a maximum outer diameter of said valve body.

10. The apparatus of claim 1, wherein said liquid channel is designed without an element acting as a gas lock.

11. The apparatus of claim 1, further comprising a circulating filling machine comprising a rotor for supporting a multiplicity of filling elements, including said filling element, said rotor being configured to be driven about a vertical machine axis.

12. The apparatus of claim 1, wherein the liquid valve comprises a valve body comprising a valve body segment that, upon commencement of opening of said liquid valve, moves along a segment of said liquid channel, wherein said valve body segment and said liquid channel segment are configured to have a geometry such that a width of said gap formed between said valve body segment and an inner face of said liquid channel segment on first opening of said liquid valve increases as said liquid valve is opened further, and wherein said valve body segment comprises an outer cross section that reduces in response to said opening movement of said valve body.

13. A method for filling a container, said method comprising free jet filling of a container with liquid charge, wherein free-jet filling comprises providing a filling-element housing comprising a liquid channel formed therein, providing a liquid valve upstream of a dispensing opening, arranging a container so that a container opening thereof is spaced below said dispensing opening, actuating said liquid valve for controlled discharge of said liquid charge via said dispensing opening into said container, wherein actuating said liquid valve comprises causing said liquid valve to transition into a completely open state during which said liquid valve forms an gap through which said liquid charge flows, said gap having a maximum width of at least four millimeters, and causing said liquid valve to reach said completely-open state only after a lapse of at least one hundred milliseconds from actuation.

14. The method of claim 13, wherein causing said liquid valve to transition into said completely-open state comprises causing said gap to reach a maximum width of between eight millimeters and twenty millimeters.

15. The method of claim 13, wherein causing said liquid valve to transition into said completely open state comprises causing said gap to attain a maximum width that is between thirteen millimeters and sixteen millimeters wide.

16. The method of claim 13, wherein causing said liquid valve to reach said completely-open state only after a lapse of at least one hundred milliseconds comprises causing said liquid valve to reach said completely-open state after a lapse of between one hundred milliseconds and one thousand milliseconds.

17. The method of claim 13, wherein causing said liquid valve to be in said open state comprises causing said liquid valve to be in said open state for between four hundred milliseconds and six hundred milliseconds.

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